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The use of massive multiplayer online games to evaluate C4I systems

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THESIS

THE USE OF MASSIVE MULTPLAYER ONLINE GAMES TO EVALUATE C4I SYSTEMS

by

Kambra Juve

March 2004

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THE USE OF MASSIVE MULTIPLAYER ONLINE GAMES TO EVALUATE C4I SYSTEMS

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ABSTRACT

In the past few years, Massive Multiplayer Online Games (MMOG) have gained in popularity in the gaming industry, the public and the Department of Defense. Improvements to computer technology and the increased data transfer rate over networks have caused the potential applications for networked environments to blossom. MMOGs are a product of these improvements, as technological advancements have made it possible for the masses to gain access to virtual environments and participate.

The ability to communicate and interact within the virtual environment has the potential to make MMOG technology an ideal tool for evaluating C4I systems. The design and evaluation of C4I systems with MMOGs has the potential to allow for exploration in the areas of warfighter effectiveness, emergent behavior, collective decision making, human systems integration and effective information flow.

This thesis strives to illustrate how a C4I system modeled in an MMOG can aid designers in gathering insights on the effectiveness of the system in various combat situations. The insights will be gathered through the interactions of players with the modeled system in the virtual environment. The human interaction with the modeled C4I system provides the ability to capture the effects of the C4I system on the warfighter. The resultant effects of the C4I system on the warfighter directly contribute to the overall combat effectiveness of the deployed military forces.

The background of MMOGs and C4I systems, and attributes of MMOGs that are desirable in evaluating C4I systems are introduced and discussed. FORCEnet, a global C4I architecture still in the conceptual phase is then used as an example to illustrate the potential rewards to using MMOGs to evaluate C4I systems.

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I. INTRODUCTION

A. PROBLEM STATEMENT

In the past few years, Massive Multiplayer Online Games (MMOG) have gained in popularity in the gaming industry, the public and the Department of Defense. These networked virtual environments are "a software system in which multiple users interact with each other in real-time, even though those users may be located around the world. These environments aim to provide users with a sense of realism by incorporating 3D graphics and stereo sound, to create an immersive experience." [Zyda99] MMOGs add a level of complexity to virtual environments due to the number of users that can participate within the environment.

The use of virtual environments is not a new concept in the DoD. Improvements to computer technology (e.g. memory, speed, graphics, etc.) and the increased data transfer rate over networks have caused the potential applications for networked environments to blossom. MMOGs are a product of these improvements, as technological advancements have made it possible for the masses to gain access to virtual environments and participate.

The purpose of command, control, communications, computers and intelligence (C4I) systems is to provide commanders with the ability to govern all activities under their purview. C4I systems encompass a wide variety of areas to include organization, equipment, requirements, procurement, training and operations. [Pendergrass93] A core requirement of C4I systems is to ensure communications between the entities that are a part of the system. The definition of a C4I system is broad and comprises three primary components: physical entities, structures, and C2 processes. The various functions (e.g. tactical, strategic, etc.) and purposes of C4I systems pose a challenge when attempting to model and analyze a system.

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Two primary types of models and simulations are available to aid in the evaluation of C4I systems; models designed to evaluate specific C4I systems and attrition based warfighting models. The first type of models and simulations are designed to analyze a specific C4I system's capacity to technologically function as intended. Though this type of M&S aids in the structural design of a C4I system, it does not produce any information concerning the contribution that the system makes to the warfighter. The second type of attrition based warfighting M&S is historically based on mathematical models and algorithms to produce battlefield outcomes. This type is used to predict the outcome of battles with certain assets but fails to take into account the advantages gained by having an effective C4I system and information.

The ability to communicate and interact within the virtual environment would appear to make MMOG technology an ideal tool for evaluating C4I systems. The design and evaluation of C4I systems with MMOGs has the potential to provide information that is lacking in current M&S, and allow for additional exploration in the areas of emergent behavior, collective decision making, human systems integration and effective information flow. The use of MMOGs to aid in the design and evaluation of C4I systems is explored in this thesis.

B. MOTIVATION

The potential of MMOGs in the DoD is still largely unexplored. In the civilian sector, online games have become a multibillion-dollar industry that continues to rapidly grow with technological advancements and increasing popularity. The online gaming phenomena caught the attention of the Defense Science Board which, in the 2001 Summer Study, suggested a Science and Technology (S&T) initiative to leverage the civilian online entertainment industry to create a military toolkit with virtual environments that support the involvement of active military in the field, support exploration in unrestricted play, and to better understand and identify emergent behavior. [DSB01]

This thesis intends to take the recommendation of the Defense Science Board to explore the potential uses of MMOG to aid in the development and evaluation of C4I systems. In addition to conducting simulations, the advantages of allowing unrestricted play with a modeled C4I architecture and the effects of emergent behavior are explored.

C.   OBJECTIVES

This thesis has two objectives:

- Introduce MMOGs, their history and the role they currently play in the military.

- Illustrate the potential advantages of MMOGs in the design and evaluation of C4I systems.

This thesis strives to illustrate how a C4I system modeled in an MMOG can aid designers in gathering insights on the effectiveness of the system in various combat situations. The insights will be gathered through the interactions of players with the modeled system in the virtual environment. Designing a C4I system within an MMOG provides the environment for designers to analyze the effects of the C4I system on the warfighter. The resultant effects of the C4I system on the warfighter directly contribute to the overall combat effectiveness of the deployed military forces.

Modeling the C4I system in the MMOG allows for analysis of the effects of the shared situational awareness (SSA) that a C4I system can provide to the warfighter. MMOGs have already proven to be an optimal technology to analyze factors such as group dynamics and emergent behavior. A C4I system modeled in an MMOG can provide these insights and allow designers to analyze unexpected positive and negative side effects of SSA.

The effects of a C4I system on warfighters will directly impact the combat effectiveness of the forces utilizing the system. The interaction of players with the modeled C4I system in the virtual environment will allow designers to gain

insights on whether or not the system increases combat effectiveness by using the system within a multitude of scenarios and environments. Any insights gained can be compared to game play conducted without the C4I system in the virtual environment to gain a better understanding of the degree of effectiveness. Additional insights can also be gained on the design of the C4I system interfaces like the displays. User interaction can provide feedback to the designers as to the effectiveness of the display layouts, the information that they provide, whether or not the interfaces are user friendly and easy to understand, and any benefits the system may add as a decision aid to commanders.

The objectives of this thesis are met by introducing MMOGs in chapter II to design and technological limitations. A definition of C4I systems is also introduced in this chapter to provide a foundation for the following chapters. Chapter III illustrates two points: MMOG technology is mature enough today to be used by the military in the capacity as a C4I evaluation tool, and MMOGs have many attributes that may aid in gaining insight into a C4I system. These points are discussed by the introduction of attributes and current MMOGs that are successful in illustrating those attributes.

Chapter IV illustrates how the attributes of MMOGs introduced in Chapter III are beneficial in evaluating a C4I system by the introduction and evaluation of FORCEnet, a C4I system currently in development. FORCEnet is the global infrastructure that will provide superior knowledge of the adversaries' capabilities, intent and employment to the warfighter via a multi-domain, tiered network architecture of weapons, sensors, platforms, and communications nodes. FORCEnet will provide rapid accumulation and dissemination of knowledge that will create a shared awareness among warfighters and provide an integrated battle space picture that will translate into executable courses of action.

FORCEnet is an excellent example to use with MMOGs since it is still in a conceptual phase and designers are facing substantial challenges like architecture, system interoperability, human systems integration, and information

flow, to name a few. The bottom line is to find out if FORCEnet enhances combat effectiveness. This thesis explores how MMOGs can aid in answering this question.

D. THESIS ORGANIZATION

Five chapters comprise this research:

- *Chapter I: Introduction.* This chapter discusses the purpose and motivation behind this thesis.

- *Chapter II: Background and History.* This chapter reviews the background of MMOGs to include a description of what an MMOG is, its components and the aspects of a virtual environment. The history of MMOGs is also discussed, and a description of C4I systems and an evaluation method are given.

- *Chapter III: Desirable Attributes of MMOGs.* This chapter highlights characteristics that are desirable in evaluating C4I systems and uses selected MMOGs and supporting technologies in the civilian and military sectors that have been successful in illustrating those characteristics.

- *Chapter IV: MMOGs and FORCEnet.* This chapter introduces FORCEnet and uses the architecture to illustrate the advantages of MMOGs.

- *Chapter V: Conclusions and Recommendations.* This chapter gives conclusions from the research and provides recommendations for future work.

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II. BACKGROUND AND HISTORY

A. INTRODUCTION

In this chapter, a description of MMOGs is provided. Design features that distinguish MMOGs from traditional virtual environments are discussed in addition to design limitations. A history of networked virtual environments that were instrumental in the advancement of networked virtual environment technologies is also given.

The second part of this chapter introduces C4I systems. A definition and description of C4I is provided in addition to critical components. The introduction of MMOGs and C4I systems provides the background information for the following chapters.

B. DESCRIPTION OF MMOGS

MMOGs are a distributed software component with a computer generated simulated space in which a multitude of users interact with each other in real time. A user interacts with the virtual environment by accessing his or her computer and using that device as the interface between the real world and the simulated environment. The user is represented within the virtual environment as an avatar or virtual persona. The avatar is a graphical representation that is often chosen or created by the user and ranges from a human-like form to a mythical creature. The avatar also has a physical and motion model that dictates the size and possible movements of the avatar in the virtual environment.

MMOGs are unique in that more than one player can interact in a virtual environment at the same time. This adds a great deal of complexity to the virtual environment. MMOGs have five common features that distinguish them from traditional virtual environments [Zyda99]:

- *A shared sense of space*. All the users interacting with a virtual environment will share the illusion of being in the same place. The actual outlay of the virtual environment is limited only by the imagination of the graphical designer but each user will be subject to the same characteristics of the

environment such as temperature and weather. This provides the common location where the users can interact.

- *A shared sense of presence*. When a user enters a virtual environment, he or she should be able to see the other users represented as their avatars. A user should be able to see the movements of the other avatars if they are within visual range within the virtual environment and other users should be able to see the user's avatar. When a user logs in, those in the environment should be able to see the avatar enter the space and conversely when a user logs off, others should be able to see the avatar depart. Avatars need not be human controlled. Artificial Intelligence can be programmed into the game and operate avatars within the environment.

- *A shared sense of time.* As an avatar moves, all users should see the movement at the same time. This real-time interaction ensures that all participants in the environment maintain an accurate picture at all times.

- *A way to communicate*. The benefit of MMOGs stems from the ability of the users to interact with each other in the virtual environment. Though visualization provides a substantial method for users to communicate with each other, the experience is enhanced by providing other means of communication like gestures, typed text or voice. Not only does this add a sense of realism to the game but is a necessary component if MMOGs are used as a training or engineering tool.

- *A way to share.* The final feature is a way for avatars to interact with each other and with the environment. Avatars need to be able to share objects and manipulate the game environment for example, pass objects, drive in a vehicle and build things.

C.   DESIGN LIMITATIONS

MMOGs provide a more fulfilling and realistic interface than mediums like instant messaging and e-mail. The challenge associated with a more realistic environment is increased complexity in the game design. The complexity of the

environment carries with it certain limitations. The following are areas that pose a challenge in game design and development [Zyda99]:

- *Network bandwidth*. The nature of MMOGs is based on the transmission of information over a data network. To maintain the shared sense of presence, the actions taken by a user must be transmitted over the network to update the picture for other users. The challenge to provide a uniform picture is increased with the amount of detail that must be updated and the number of users participating in the environment.

-*Heterogeneity*. The goal of heterogeneity is to provide a level playing field for all users. This provides a challenge to designers due to the various equipment and network speeds used by the participants.

Since the users of an MMOG are using their personal or work computers to access the virtual environment, the equipment used by the users will not all be the same. Some users may have a simple set up of a keyboard and mouse whereas other may have the latest gaming equipment. The users' computers also vary in CPU speeds, graphical displays, and audio capacity. Some users may have gaming computers that have a high capacity for graphics, a CPU that can process data rapidly to update the picture and audio enhancements whereas others may have a low end PC with slower processing rates and minimal ability to handle graphics.

Network capacity is also a consideration since user network capacities will range from high capacity broadband connections to dial up modems. This affects how rapidly data can be transmitted to update the common picture for each of the users. In order to keep the game interesting for all users, a level playing field needs to be established to ensure broadband users do not have an advantage over dial up users. This results in reducing the system to the "lowest common denominator" where the network capacity is no greater than the lowest capacity link. In the gaming industry today, games are commonly reduced to the level of 56k modems.

- *Distributed Interaction*. One of the defining qualities of an MMOG is the ability of users to see their actions and the actions of others in real-time. In reality, this is impossible due to the delay imposed by the transmission time over the network. The illusion of a single server game can only be achieved by recognizing that data received is already out of date by the time it is received by the user's computer and having the host computer compensate for the delay. This poses a challenge for game designers who must resolve issues such a collisions between avatars and objects even though data are received by users at different rates.

- *Scalability*. Scalability or size of an MMOG is defined by "the number of entities that may simultaneously participate in the system. An entity is a participating object that is separately modeled by the participating hosts." [Zyda99] Entities can be mobile objects or logical objects like the current weather state. Scalability can also be measured by the number of participants that are able to connect to the game and the physical distance between users.

The complexity of a game environment theoretically increases exponentially with the number of entities due to the possibility of interaction between those entities. This results in a n(n-1)/2 (n=number of entities) possible entity-to-entity interactions. In reality, this is an unrealistic estimate since every entity in the environment will not interact with every other entity. It is rare that every user in the environment will be at the same place at the same time. Most likely, users will cluster in smaller groups in different parts of the environment.

- *Real-Time System Design*. Real-time system design addresses the problem of managing CPU usage so that all tasks with real-time constraints are met. This includes processing inputs from connected devices like keyboards and mice in addition to incoming packets that produce the graphical representation of the game. Designers must consider how to manage the CPU time to ensure the game environment remains realistic while completing tasks with real-time constraints. Two approaches exist to handle this problem. The first approach is to place everything into a single thread and cycle them thorough the CPU fast

enough so all real-time constraints are met. The second approach is to have multiple threads that are scheduled for CPU processing.

- *Failure Management.* In a networked system, numerous areas exist where a failure can occur. Designers must create contingency plans for when failures happen to minimize down time and damage to the gaming environment. There are four types of system failure. The first is *system stop* where the failure occurs in a resource critical to the game's execution. The game is no longer operable. This is the least desirable of all the failures. The second area is *system closure*. In this case, the failure occurs in a non-critical resource so the game can continue to run but no additional users can enter the environment. The third area is *system hindrance*. This area encompasses a broad range of failures that may degrade the gaming experience but not stop the game. The final area is *system continuance*. Any failure that occurs that has no noticeable affect on the gaming environment falls into this area. This is the most desirable of failures if a failure should occur.

D.   HISTORY OF MMOGS

The evolution of MMOGs has resulted in many successful games over the years. The primary groups that have conducted research are the military, academia, and the commercial gaming industry. The Department of Defense (DoD) was the largest developer and the first to conduct research on large-scale networked virtual environments. Unfortunately, a great deal of the paperwork documenting DoD's earlier work was lost, so academia was forced to reinvent a great deal of the wheel and recreate and expand networked virtual environments for their own purposes. The commercial industry recognized the benefits of multi-player games early on and basically paralleled the research conducted by the DoD. The successful games are too numerous to mention, so a few prominent examples will be highlighted in each field.

The following table lists a few of the systems that have had a significant impact on the evolution of MMOGs and their related areas:

FIELD	SYSTEM
Department of Defense	SIMNET
Academia	NPSNET
	BrickNet
Commercial Systems	SGI Flight and Dogfight
	Doom

Table 1.   Historical MMOG Systems

1.   DoD Networks

SIMNET.   Simulated Networking (SIMNET) was created for DARPA by Bolt, Bernanek and Newman (BBN), Perceptronics and Delta Graphics.   The objective was to design a distributed military virtual environment.   The program began in 1983 with the initial goal of constructing a series of sites that hosted 50 to 100 simulators at each site.   The program hosted platforms such as tanks, personnel carriers, helicopters and A-10s.   The final SIMNET testbed consisted of 250 simulators at 11 sites.

Challenges that existed while creating SIMNET were 1) how to fabricate high-quality, low cost simulators and 2) how to network the simulators together to create continuity in the virtual space [Miller/Thorpe95], [Zyda99].   It is questionable if the first challenge was overcome as the cost of a simulator in 1993 was still $350,000.   The second challenge was addressed as the network expanded.   Eventually, SIMNET could be entered by using a simulator as the

portal to the virtual battlefield. The user was able to interact with other participants online in either an unscripted, free play fashion or within guidelines placed on the session.

2. Academic Networks

NPSNET. The NPSNET Research Group is the longest running academic research effort in networked virtual environments. The focus is to advance networked virtual environment technology for use by the DoD. The software, formally named NPSNET has undergone numerous revisions to produce several generations of the software. NPSNET software is the testbed for the NPSNET Research Group.

NPSNET originated with a student class project in 1986 when two students created a visual simulator for the fiber-optically guided missile (FOG-M) system. The FOG-M system, combined with software architecture code created by Professor Mike Zyda from the Naval Postgraduate School, enabled the program to be networked. The follow on system to FOG-M was VEH, a target vehicle simulator. The objective was to make the FOG-M program more realistic by enabling the target to move. This was accomplished by connecting the FOG-M and VEH programs. The success of the outcome in July 1987 inspired the NPSNET group to continue research and experiment with more participants on the network.

As is common with large bureaucracies, the right arm is not always familiar with what the left arm is doing. Such was the case between the research efforts of SIMNET and NPSNET. Fortunately, by 1988, the two projects were known to each other and were able to progress together. The follow on software intended to advance both projects was NPSNET-1. The objective of the software was make NPSNET and SIMNET compatible by enabling NPSNET to read SIMNET terrain databases. The success of NPSNET-1 was significant because the functionality of SIMNET would now be available on regular computers instead of being limited to SIMNET simulators.

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NPSNET-2, NPSNET-3 and NPS-Stealth were the next generations of NPSNET software. The objectives of NPSNET-2 and NPSNET-3 were to explore better, faster ways to do graphics and to extend the size of the terrain. The objective of NPSNET-Stealth was to continue exploration of interoperability issues with SIMNET. In March 1993, NPSNET-Stealth was the only workstation based virtual environment capable of interoperating with the SIMNET system [Zyda99].

Inspired by the Performer API released by Silicon Graphics in 1993, the NPSNET Research Group decided to build NPSNET-IV. The NPSNET software had evolved to the point where players could be represented by a realistic human representation in the virtual world, operate an assortment of air, surface or sub-surface platforms and walk through buildings. In addition, NPSNET-IV was the first software generation that was Internet capable.

NPSNET-V is the latest generation of the NPSNET software. This version of NPSNET was implemented with the following goals in mind [Serin02]:

- Run-time extensibility for both content and applications

- Scalability in world complexity and number of participants

- Composability of heterogeneous content and applications

As stated by McGregor and Kapolka, the implementers of NPSNET-V, the dream of NPSNET-V is for it to be "… a framework for fully distributed, component-based, networked virtual worlds, extensible at run time and scalable to infinite size on the Internet" [McGregor01], [Serin02]. The benefit of run-time extensibility is being able to add components and behaviors to the virtual environment without interruption.

BrickNet. BrickNet was created by Gurminder Singh, a professor at the Naval Postgraduate School. The project started in 1991 with the goal of developing a networked infrastructure to enable multiple environments with different contents to communicate [Singh97] [Zyda99]. BrickNet offered an alternative to replicating complete databases for each client by partitioning the

virtual world to different computers and having those computers share information to create a complete picture. This allowed multiple virtual worlds to share objects.

The partitions would be stored on separate servers that hosted clients. Communication would then occur between servers to share information when necessary. The structure between servers and hosts eliminated the requirement for every client to have the entire picture but enabled them to access data from other servers when needed.

This system was designed to support collaborative design environments where each member of a design team is responsible for a piece of the project. A member of the team could update their section, and in a collaborative effort, the system would update that picture for all the users. One disadvantage to the system is the latency issues that are introduced by having a distributed picture. This limited the number of participants that could interact with the network. The largest BrickNet experiment included 8 participants, though the architecture can support up to 32 users.

3.   Commercial Networked Games

SGI *Flight* and *Dogfight*. The *Flight* demo was created by Gary Tarolli of Silicon Graphics, Inc. (SGI) and released in 1983. In the program, the user was able to select an aircraft and maneuver the aircraft using a keyboard. The objective of the game was to demonstrate the capabilities of an SGI workstation to allow a user to operate within a 3D world.

In 1984, networking was added to the demo in stages and was eventually added to all SGI workstations. The networked version of the game allowed users to see each other's planes, though interaction between players was not possible. The next enhancement of the program occurred in 1985 when the code of *Flight* was modified to create *Dogfight*, a program that allowed players to interact with each other. The interaction allowed players to shoot each other down. The game became so popular with employees that work productivity began to drop.

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The game was eventually removed from many SGI workstations. The significance of *Flight* and Dogfight was the inspiration that they provided to those who purchased SGI computers and most likely inspired further development in the MMOG field.

Doom. The first version of *Doom* was released on 10 December 1993 by id Software. The game was a first person shooter game in a 3D environment. The environment was a place overrun with toxic waste and monsters. In a networked environment, users would combat other monsters operated by other players.

The release of Doom caught the attention of network administrators everywhere when LAN started to get bogged down everywhere. Players were able to participate in a 4-person LAN or head to head modem competitions. The demand for 3D environments only increased as the exposure to *Doom* spread.

id Software was able to tap the innovations of the masses by releasing the source code for Doom and allowing modifications to be made and distributed, as long as everything was free of charge. The game took on a life of its own as enthusiasts created new levels and modifications to the game. Many of id Software's employees were discovered this way.

Doom has continued to gain momentum over the years. *Doom II* was released in October 1994 and sold over 1.6 million copies. Several episodes of *Doom II* exist like *Ultimate Doom* and *Final* Doom. The latest version *Doom III* was released early January 2004 [id Software04].

E.   DESCRIPTION OF C4I SYSTEMS

In order to understand C4I systems, it is important to understand the concept of command and control. Per the Joint Chiefs of Staff (JCS) Pub 1-02, the definition of command and control is:

The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities and procedures which are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

The definition implies three separate notions. The first is the concept of the command function or responsibility. The second is a command and control process that performs the function. The third concept is the physical entities that make up the command and control system. C4I systems are related directly with the third concept of physical entities.

C4I systems are the technological, organizational and doctrinal systems that provide three functions: the delegation of forces (command and control), information management (communications and computers) and intelligence dissemination. [Pendergrass]. In short, a C4I system is the architecture for data, communications and intelligence updating that is intended to get the critical and relevant information to the right people, at the right place and at the right time. Specific objectives of C4I systems include the following [JCS Pub 6-0, 95]:

- *Produce a Unity of Effort.* A C4I system should increase combat effectiveness by allowing collaboration between multiple commanders, key warfighters and the experts on any given task.

- *Exploit Total Force Capabilities*. C4I systems must be planned as an extension of human senses and processes to aid the commander in developing a clear picture of the combat situation. A heightened sense of awareness can aid the commander in making a more educated decision and increase combat effectiveness.

- *Properly Position Critical Information.* C4I systems must be able to respond rapidly to requests for information and direct that information to all parties that require the information in the necessary format.

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- *Information Fusion.* C4I systems should be able to fuse the information provided by a multitude of sources and create an accurate picture of the battlespace that meets the needs of the warfighters.

C4I systems comprise the following major components [JCS Pub 6-0, 95]:

- *Terminal Devices*. The most frequently used terminal devices are telephones, faxes, and computers, though other devices such as handheld consoles are becoming more prevalent. The goal of terminal devices is to transform information between comprehensible forms useful to the warfighter and a format suitable for data transmission through the system. [The purpose of terminal devices has expanded to include information to aid the cognitive process of the commander in making decisions, and functioning as a collaboration system.]

- *Transmission Media*. Transmission media are the mediums that transmit data through the network. Common transmission media are radio (including space based transmission), metallic wire and fiber optic cable. Transmission paths can vary between point-to-point or point-to-multipoint if the path serves a multitude of subscribers.

- *Switches*. Switches route traffic through the transmission media. Switches are versatile mechanisms that can be manual or automatic, be used locally or perform area network functions. The two primary types of switches are circuit and packet. Circuit switches generally support telephone transmissions while packet switches process data transmissions.

- *Control*. There are two basic levels of control: network and nodal. Network control provides management of area, regional, theater or global networks. Network controls are primarily responsible for the management and configuration of long haul transmission media and switching centers. Nodal control handles the management of local networks. It handles the switching networks that transmit information between the local networks and the terminal devices used by the warfighters.

Ideally, a C4I system provides a continuous, uninterrupted flow and processing of information in support of warrior planning, decision and execution. The system is interoperable, flexible, responsive, mobile and disciplined, survivable and sustainable. Commanders and warfighters can gain access to the necessary information through the system and that information will be provided where, when and how the requestor wants it.

F. EVALUATION CRITERIA FOR C4I SYSTEMS

Numerous challenges exist in evaluating C4I systems. The primary challenge is determining the measures by which to evaluate the C4I system. This includes factors such as the measures of effectiveness (MOE), measures of performance (MOP) and measures of force effectiveness (MOFE). The follow on challenge is gathering quantifiable data that allows the designers to evaluate how the system performs in terms of the selected measures. Another major challenge is the creation of a standard approach that can be used to evaluate a multitude of C4I systems that perform various functions. Irrespective of a particular model, certain factors must be taken into account when evaluating a C4I system: [Bean94]

- The model used to evaluate a system must be understood and agreed upon by all types of users for both conceptual and implementation applications.

- The model must represent all the functions addressed by a C4I system as well as serve as a building block for analysis of the individual components of the system.

- The model must have the ability to clearly define a boundary between the C4I system and the non-C4I components (external environment).

- The model must allow for representation of time and organization among and within the C4I entities.

- The model must provide the ability to represent the internal dynamics of the C4I system as well as the interactions of the C4I system with the environment.

- The model must provide the framework for measuring the C4I system at three levels: MOE, MOP, and MOFE.

- The model must consider human decision makers from the standpoint of cognitive decision processing factors

- The model must provide the ability to represent information transfer.

One general approach to evaluating C4I systems that incorporates these factors is the Modular Command and Control Evaluation Structure (MCES). This approach has been applied to address issues during planning, acquisition, testing and operation phases of a C4I system. It also aids designers in focusing on problem definition and design issues instead of focusing prematurely on quantitative issues. MCES comprises seven steps: 1) Problem formulation, 2) C4I system bounding, 3) C4I process definition, 4) integration of system elements and functions, 5) specification of measures criteria, 6) data generation, and 7) aggregation of measures [Kramer87].
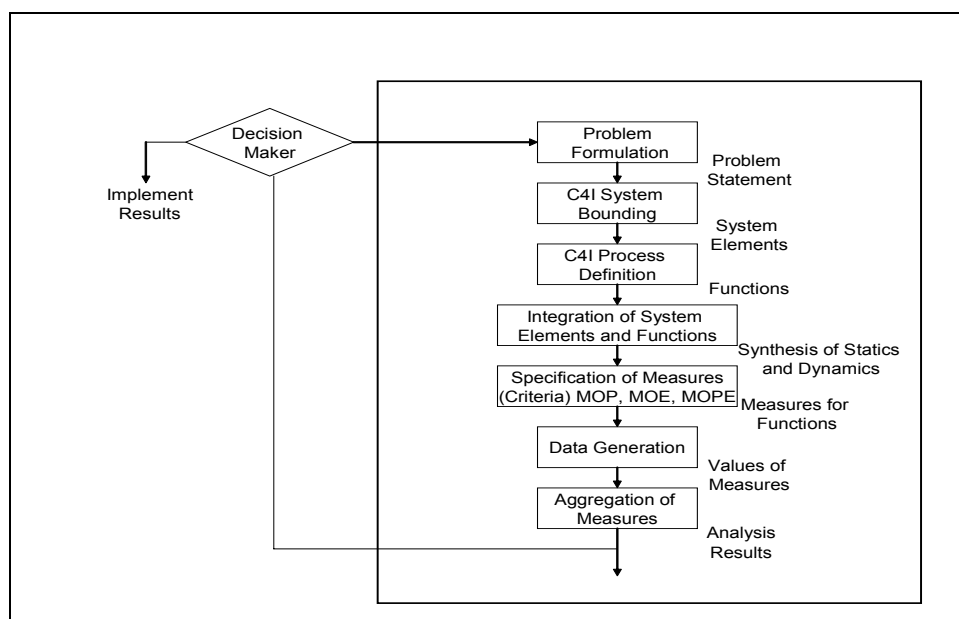
Figure 1.   Modular Command and Control Evaluation Structure

The first step of the MCES is to identify the objectives of the evaluation. The objective is derived from analyzing 1) the mission of the system, 2) the type of system, 3) the timing, scope and criticality of decisions made concerning the system, and 4) the background and commitment of the decision makers. The result of this step is the formal problem statement. The second step is to bound the system by delineating the difference between the system and the environment. The system in this step is identified by its physical entities, and its structure. The system is then related to the forces it controls and the environmental stimuli to which it responds e.g. the enemy.

Step three focuses on the process of the C4I system. The focus is on the environmental initiators of the process, the internal process of the system and the input and output flow of information. Step four integrates the physical structure of the system identified in step two with the processes identified in step three. The outcome of this step is the creation of an "architecture" that outlines the integration of interfaces and subsystems and the mechanisms for control of the system.

Step five entails the selection of measures to evaluate the system. The specification of a set of measures creates the construct for the evaluation of the process functions of the system, the overall performance, and the force effectiveness of the system when combined with forces and weapons systems. Step six addresses the collection of data for the various measures set in step five. Data can be collected through activities such as testing, simulation, computational modeling or subjective evaluation. The final step aggregates all the data collected and interprets the information to produce tangible results.

G. SUMMARY

The background of MMOGs and C4I systems are presented in this chapter to provide the foundation to build a connection between the two topics. In addition, the Modular Command and Control Evaluation Structure (MCES) is introduced to provide a framework for the evaluation of C4I systems and to highlight the places where MMOGs can be used to enrich the process. Though C4I systems come in a variety of designs and are inherently complex due to the number of components that comprise the systems, using a virtual environment within the framework of MMOGs can provide the opportunity to identify design flaws and problem areas, and highlight successes. Current MMOG successes are discussed in Chapter III to illustrate certain aspects of the technology that can be used to evaluate C4I systems.

III.   DESIRABLE ATTRIBUTES OF TODAY'S MMOGS

A.   INTRODUCTION

In this chapter, a connection between MMOGs and C4I systems is developed by the introduction of desirable attributes of MMOGs that can be instrumental in evaluating C4I systems.   Current military and commercially designed MMOGS and supporting technologies are used to illustrate the application of the addressed attributes.

B.   TODAY'S MMOGS

MMOGs have experienced resounding success over the past few years. A study conducted in 2002 by Zona, a supplier of network solutions, estimated the value of the worldwide electronic game industry at $31.7 billion with $150 million a year in MMOG monthly subscriptions [EuropeMedia02].   Though the skyrocketing popularity of MMOGs can be attributed to numerous factors, important ones to note are state-of-the art graphics, a high entertainment value, user-friendly interfaces, advanced automated intelligence (AI), and the increased data transmission rates available to users.

1.   Accurate Gaming Environment for All Participants

The study conducted by Zona in 2002 [EuropeMedia02] identified a high correlation between the popularity of MMOGs and the number of broadband connections available to users.   MMOGs were more popular in countries with a larger percentage of broadband-wired homes.   During the time of the study, 25 percent of homes in the U.S. were broadband connected, 40 percent in Japan and Germany, and over 70 percent in South Korea.   The study also identified South Korea as one of the countries with the highest percentage of the population who subscribed to MMOGs.

South Korea is an interesting example of creating an immersive environment in MMOGs through broadband connections and additional events.

Gaming is particularly attractive to the 48 million residents with 16 million households wired with broadband connections and 25,000 Internet cafes that provide broadband access to anyone else. In addition, the gaming craze has spawned four 24-hour cable channels that air professional gaming events and fan clubs for gaming superstars that draw tens of thousands of members [Korea Herald04].

Out of the 800 games available in South Korea, the game that monopolizes 34% of the market is NCSoft's monster hit, Lineage. Unveiled in 1998, Lineage became an overnight success and continues to gain momentum. Lineage is set in medieval times where the players can choose to be characters like knights, sorcerers, elves, princes or princesses. The environment consists of well guarded castles, perilous forests and valleys filled with the undead. As the characters move through the virtual environments, they have the opportunity to meet other players, embark on new adventures, and make alliances to aid in conquering any challenges presented.

The game appeals not only to the first person shooter crowd but also those interested in the social aspect of MMOGs. The virtual environment can act as a glorified chat room where players can communicate via text or voice and interact through their avatars. Players have the opportunity to meet a variety of other avatars or participate in the social structure created by the players in the game. Places such as taverns and markets within the virtual environment provide a place for players to relax and socialize with other players and boast about their exploits in the game.

The appeal of Lineage is due in part to the amazing life-like graphics that comprise the gaming environment. The gaming environment is made in such great detail to create a realistic, immersive picture. This can be instrumental in evaluating C4I systems to ensure a common operating picture for all the participants. Accuracy must also be maintained in the portrayal of transmission media in the virtual environment and the C4I displays being evaluated.

Figure 2.   Lineage Screenshot [Lineage04]

The price paid for amazing graphics, a large gaming environment and the ability to communicate with other players, is the amount of information that must be transmitted between the game servers and the participants' gaming devices. This is a major reason that South Korea and its highest per capita broadband connections was a prime location for the introduction of MMOGs. The speed of data transmission aids in maintaining a clear, smooth accurate picture of the gaming environment.

In principle, in order to maintain heterogeneity, games are designed to the lowest common denominator or the slowest transmission rate (usually 56k modem speed). Realistically, those using a 56k modem will see a choppy picture on their gaming device as information will not be able to be transmitted rapidly enough to keep the picture up to date. The increased data transmission rates provide the user with a realistic and immersive gaming environment.

Providing an immersive gaming environment is critical in evaluating C4I systems. All participants should maintain an accurate picture at all times, especially when split-second decisions are made and actions are taken. A choppy picture or delay can potentially cause the illusion of a design flaw in the C4I system being evaluated if a player's inaction or mistake is caused by the lack

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of updated information.   At the same time, malfunctions should be incorporated into the testing of the C4I systems since it is probable that connectivity failures will occur in the field.

2.   Multiple Environments

A variety of operating environments is crucial in evaluating C4I systems. In today's operating environments, C4I systems span across regions to forces operating in a variety of conditions.   The effects of the distances spanned between nodes and the effects of the environment are crucial aspects that must be evaluated.   The scalability of the virtual environment allows for large areas and various terrains to be modeled and for a system to be tested throughout the environment.

A current example of the expansiveness of an online environment is Everquest, the number one MMOG in the world today. The Everquest world of Norrath comprises five continents that players can move between.   The five continents are Antonica, Odus, Faydwer, Kunark and Velious. Each continent has a variety of terrains ranging from thick forests to desert. Large cities, located on several of the continents, offer an environment for urban combat.   The continent of Velious offers a unique Antarctica type environment of frozen lands, icy waters and icecaps.

Each continent not only has a composition of unique terrains but a different set of inhabitants. An example is the continent of Kunark that is filled with ancient ruins and hostile lands. The inhabitants were formerly a great and powerful reptilian race and are fighting to reclaim their past glory. They perceive any visitors as hostiles and treat them as such. Odus, on the other hand, is inhabited by the Erudites, an enlightened group of individuals whose hostile actions were limited to evicting the native inhabitants of the continent and exiling them to the small Isle of Kerra.

Figure 3.   Continent of Antonica in Everquest [Everquest04]

Players have the opportunity to move between the continents and must face new challenges in each place. The game environment adds additional challenges and game space by hiding different planes and dimensions that players can enter, allowing players to explore worlds beyond the known hemisphere and discover new places. Sony has also released six expansion packs that have increased the size of the game environment and provide fresh, new adventures for users to embark on. The latest expansion, Everquest: Gates of Discord, is adding the lost continent of Taelosia to the gaming environment, to include a massive assault force that is wreaking havoc on the continent.

A multitude of operating environments is not only crucial to testing C4I systems but is a reality in today's military operating environment. The C4I system must become more complex due to the variety of operating environments that users will be located in and the size of the footprint. An example is a C4I system that connects a stateside command center with operating units afloat, subsurface, airborne and on land. In order to create an accurate depiction of the C4I system and a realistic testing environment for the users, multiple environments must be used. This will allow evaluators to analyze combat effectiveness of units receiving data from others in different operating

environments. In addition, the resilience of the system must be tested to evaluate how the system behaves when nodes are destroyed by the enemy.

3. Effective Gaming Displays

Displays that are available to warfighters are crucial in distributing the required information to the users in an understandable format. Display effectiveness is an aspect that can be tested in the virtual environment, though it is not a replacement for live testing with actual devices. Testing displays in the virtual environment has an added level of complexity because the user has two challenges: learning how to use her gaming device to interact with the virtual environment, and using the display that is being tested. If testing various displays is the objective, the players must already be proficient in the device interface (e.g keyboard, gaming console, etc.). This will enable the displays to be tested, not the user interface.

Game displays face the challenge of displaying a multitude of factors at once to include the current environment, a chat screen, the status of the player (fatigue, injuries, etc.), and a variety of other items that may be specific to the game being played. The previous example of Everquest is used to illustrate this point.

Figure 4.   Everquest Displays [Everquest04]

In Figure 4, two Everquest displays are shown. The left screenshot is a game display that a player would see most of the time while maneuvering around the environment. The main picture in the display is the virtual environment that the avatar "sees" while moving around. The box in the top right is the player window that identifies that player's health and stamina. The box below that is the group window that displays the health and stamina status of the other players in the group, if the player is operating in a group at that time. The two larger boxes that are on the bottom half of the display are chat boxes. The largest box is the main chat box while the smaller box is an optional chat box that can be displayed when a specific chat session is desired.

The display on the right is the inventory of the player. This screen is a separate display that the player can call up to determine their inventory status, then close so that they can return to their primary game screen. The left of the screen identifies the avatar and its statistics. The center of the display identifies the items that the avatar is currently wearing. The items listed on the right side of the display are other inventory pieces that the avatar possesses but is not currently wearing.

Screens that can be called up by the player are particularly useful in evaluating C4I displays. When certain displays like map screens need to be tested, the player can call the display up, as necessary, to determine their position and potentially the locations of other friendlys and enemies, then close the screen. Other displays specific to the C4I system being tested can be inserted and tested in the game in this fashion.

A variety of other displays are available in other games. The design of the display has a direct effect on how quickly the player learns to use the game and the player's effectiveness in the game. A user friendly layout and icons provide the player the information they need to be effective in their game play. The speed at which users become familiar with game displays can also provide valuable information to C4I system designers.

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The effects of well designed displays are similar in games and C4I systems. Creating a display with the user in mind is a crucial aspect of Human Systems Integration (HSI), the synergy of humans and technology from the initial component design, through testing and production, to operations and training. The use of HSI has been successful in reducing operator errors, a reduction in time required to train operators, and saved money [SSG01]. By taking an HSI approach, MMOGs can aid designers in creating effective displays by allowing users to interact with the displays and provide feedback on their layouts, the available information, and whether or not they are beneficial.

4. Entertaining to Military Forces

One aspect crucial to the success of MMOGs in the commercial industry is the entertainment factor. One particular genre of games that is experiencing increased success is military based games. Military games that topped the gaming lists in 2003 included Medal of Honor, SOCOM II: U.S. Navy SEALs and America's Army: Special Forces [Bray04]. America's Army is especially appealing as an example due to its overwhelming online success and the fact that it was designed by the U.S. military and is used extensively by military members.

America's Army was designed by the MOVES Institute at the Naval Postgraduate School. The objective of the project was to provide an environment for young Americans to explore Soldiering in the Army while gaining insight into the Army and its values, its Soldiers and the missions that they conduct [America's Army03]. By utilizing online gaming technology, the designers created realistic virtual experiences that were accurately based on various training evolutions that an Army recruit would go through. The original release of the game, America's Army: Operations was released on July 4, 2002.

Figure 5.   America's Army Screenshot [America's Army04]

Though the intention of America's Army was to enlighten potential Army recruits into the world of Soldiering, the entertainment value of the game appeals to a far greater audience. The game has achieved such a large audience with military members that additional servers are being added by NetFire to accommodate the increasing number of players. The additional servers are intended to expand and enhance service to military members and their families stationed in Europe. The new service is scheduled to be fully online by May 2004 [Game Daemons03].

The success of America's Army with military members indicates that an online game designed by the military has the potential to engage and stimulate military members on a volunteer basis and during their free time. By providing an entertaining environment, thousands of hours have been spent by military members playing the game. In addition to the entertainment factor, the hours of game play have the potential to serve two purposes: honing the skills of the player and testing the game environment.

Harnessing the man hours and the interests of the players can provide a great deal of testing time for a modeled C4I system. The additional hours of testing can prove to be beneficial though it is important to recognize that creating an entertaining game does not necessarily translate into realistic simulations.

Providing a purely entertaining gaming environment may result more in emphasizing the creativity and imagination of players instead of physical and decision-making realities [Highlands ForumXX].

5.   Enhancement of Gaming Environment with AI

Artificial Intelligence (AI) has been a part of video games since video games first came out. In single player games, all the animations that the player would combat were run by the computer. The animated object followed a set of rules to move through the game environment and make decisions in reaction to the player's actions. Advancements in the technology combined with the increase in computer speed and data transmission rates have made it feasible for AI to be widely used.

The logic and routines that drive the AI characters in an environment play a crucial role in the success of the game. An example of poor AI design is a predictable reaction of the AI character to a stimulus or move made by the real player. The game then becomes a matter of memorizing the reactions of the AI character in order to defeat it. When this happens, the game no longer poses a challenge to the player, thus becoming less interesting.

AI has come a long way in the past few years and programmers now have options when creating their AI. Companies like AI.Implant have created a library of AI routines that can be combined to create the desired character appropriate for the game in development. The library provides designers with two advantages: a wealth of routines to choose from and a reduction in design time since they no longer have to write routines and logic from scratch. The advanced routines have enabled the creation of AI characters with a more accurate method of navigating through the game environment and a sophisticated method of decision making that allows the characters to improvise their actions and interact with other objects in the environment [AI.Implant for Games].

Another powerful tool that is available to create AI is DirectIA. The agent-based toolkit gives life-like characteristics to game characters, including physiological, psychological and emotional states. These internal states motivate the agents by giving them needs, desires, and emotions; all of which are taken into account simultaneously. The most innovative feature of DirectIA's technology is its learning capability that allows artificial characters to benefit from their past experiences, optimize their current behavior and learn new, complex ones [AboutAI.net]. Though the technology has been used extensively in gaming environments, the MASA Group (the developers of DirectIA) has focused its attention on applying the DirectIA kernel to military simulations. The enhanced simulations strive to allow greater autonomy for automated entities, reduce the number of operators, and to delegate missions to automated commanding units [MASAGroup].

There is no question that AI is necessary and important to MMOGs that are used to evaluate C4I systems. Gaming environments will need to be complex in some scenarios (e.g. urban combat) and may require AI characters to provide the necessary support or opposition to make the scenario realistic. In addition, the reduced design time in creating characters is especially important when the environment is initially developed or modified to provide a different scenario for testing.

6. Persistence and Emergent Behavior

The concept of persistence is unique identifier for many MMOGs. A persistent environment is a world that continues to change whether or not any particular user is logged onto the game. Since players are constantly interacting with the gaming environment, the virtual environment continues to evolve as game play continues. The continuous availability of the gaming environment can prove to be advantageous to players, especially if they are geographically distributed in many time zones.

The advantage to a persistent environment is a more immersive experience since it mirrors the constant change prevalent in real life situations. For many of the commercial MMOGs available today, the persistent environment fosters the ongoing sense of social connection among the users, who return to the persistent environment on a daily basis [Gehorsam03]. One outcome of the relationships developed within the persistent environment is emergent behavior.

Emergent behavior is directly attributed to the combination of multiple players in MMOGs and the persistent environment where the players intact. As the players interact within the persistent environment, their reactions influence each other. The rapport that develops between players causes groups to form and decisions between the players to become more complex [Maney03]. The groups will then make collective decisions on how to address challenges presented to them in the virtual environment.

The group's course of action tends to be notably different from the action of an individual player when facing the same challenge. This group behavior has affected commercial game design since developers must now take into account group dynamics and make game adversaries formidable enough to pose a challenge to a group attack. The difference in group and individual decision making is important in understanding the effects of providing a C4I system that will link forces together to provide a shared situational awareness (SSA). It can also provide insight into the dynamics of current and potential adversaries.

A persistent environment combined with a multitude of players provides an excellent opportunity to study group dynamics and the effects of SSA. Using MMOGs can provide the environment to evaluate the effects of SSA and whether it improves combat effectiveness. The emergence of or change in established group dynamics is also a factor that directly affects combat effectiveness and can also be studied. Unexpected side effects of SSA can also be identified like the micromanagement from the upper echelons of command. In order to fully recognize the effectiveness of SSA and the advantages it affords to its users, a comparison must be made between game play with SSA and without.

C.   SUMMARY

This chapter has outlined a number of desirable characteristics of MMOGs that can be instrumental in evaluating C4I systems. The number of successful MMOGs and supporting technologies that are available in the commercial market today indicates that MMOG development and implementation for the military is feasible today. The next chapter will utilize the information presented thus far in this thesis and use the example of FORCEnet to outline how an MMOG can aid in the design and evaluation of the C4I system. FORCEnet will be evaluated within the context of the MCES to provide the format for evaluation.

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IV. MMOGS AND FORCENET

A. INTRODUCTION

This chapter will build on the concepts introduced in Chapters II and III. FORCEnet, a revolutionary C4I system still in the design phase is introduced. The desirable attributes of MMOGs introduced in Chapter III are then used to demonstrate the advantages of the technology in the development and design of FORCEnet. The MCES introduced in Chapter II is used as the construct to evaluate FORCEnet.

B. FORCENET INTRODUCTION

Today's operational environment is segmented in a way that limits the full combat potential of our forces. The three primary domains are air, ground and maritime. Warfare across these domains is managed by designating specialized engagement zones that are created to reduce the risk of fratricide and to deconflict sensor coverage. [Hesser, Rieken04] Unfortunately, the designated engagement zones sub-optimize the capability of today's weapons systems and sensors. The field of view of a sensor and the range of a weapon system are not fully optimized since the systems are restricted by the area they can operate in. Sub-optimization will only increase as these systems become more advanced.
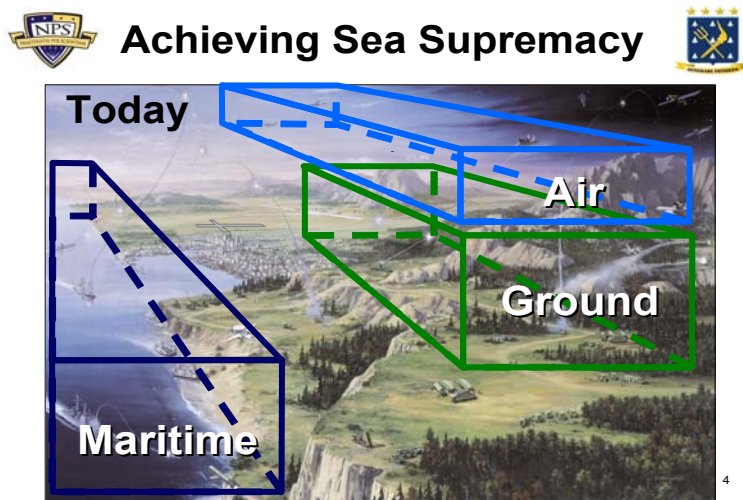

Figure 6.   Today's Operational Environment [SSG03]

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The next generation of warfare concepts addresses these sub-optimization problems that the military faces today. The solution lies in network centric warfare (NCW) and the Navy's theoretical implementation of the concept, FORCEnet. NCW has three primary themes [Moore96]:

- The shift in focus from centralized (i.e., platform-centric) resources to distributed (i.e., network-centric) resources.

- The shift from viewing actors as independent to viewing them as part of a continuously adapting ecosystem.

- The importance of making strategic choices to adapt or even survive in such changing ecosystems.

The Chief of Naval Operations' Strategic Studies Group XXI defined FORCEnet as [SSG01]:

The operational construct and architectural framework for naval warfare in the information age that integrates warriors, sensors, networks, command and control, platforms, and weapons into a networked, distributed combat force that is scalable across all levels of conflict from seabed to space and sea to land.

FORCEnet is the core of the Navy's most recent concept of operations SEA POWER 21. SEA POWER 21 consists of three primary areas, Sea Strike, Sea Sheild, and Sea Basing. "Sea Strike is the ability to project precise and persistent offensive power from the sea; Sea Shield extends defensive assurance throughout the world; and Sea Basing enhances operational independence and support for the joint force." [Proceedings02] FORCEnet is the "glue" that binds the three areas to enable SEA POWER 21.

FORCEnet integrates a broad range of assets to include weapons, sensors, platforms, communication nodes, warfighters, planners and supporting systems into a highly adaptive human-centric comprehensive system. The system will be scalable, robust, secure, interoperable, collaborative and have plug and play functionality. The collective synergy enabled by FORCEnet will provide the warfighter with self-synchronization capabilities, remote sensor engagements, joint shared battlespace awareness, and human centered integration.

The physical architecture will consist of a multi-tiered grid that includes sensors, weapons and communications nodes ranging from the seabed to space and from sea to land. Each of the nodes connected to the network will be able to collect, receive and transmit information. The data collected from each of the nodes will aggregate to create an accurate real-time picture of the battle space that is available to warfighters and decision makers. FORCEnet's architecture will theoretically resemble Figure 7.
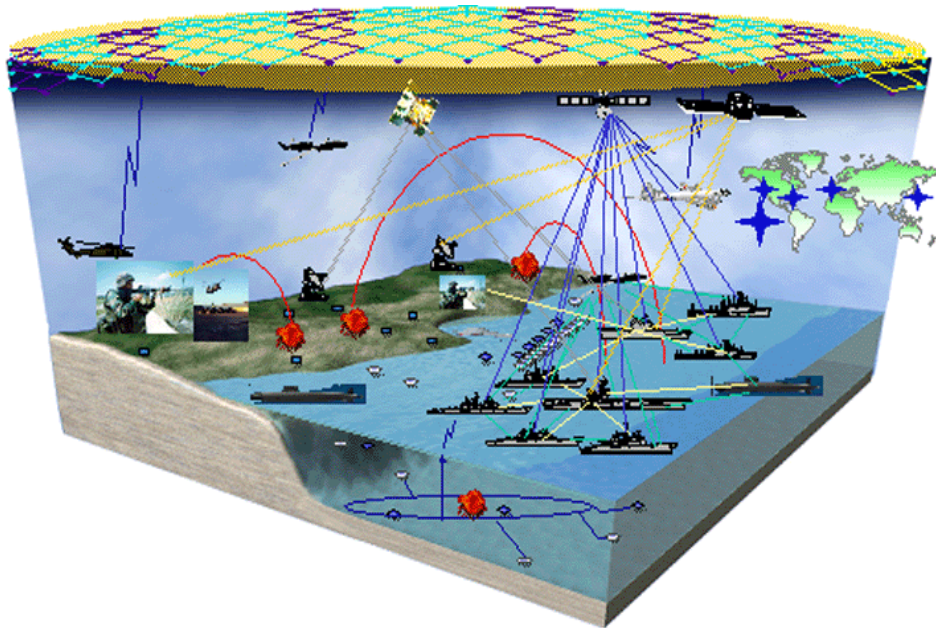

Figure 7.   Hypothetical FORCEnet Architecture [Hesser/Rieken04]

The concept of FORCEnet involves such a large number of assets that it is difficult to find a place to start when trying to create an architecture. The recent concept of FORCEnet Engagement Packs (FnEP), developed by SSGXXII, has provided a solution to the implementation of FORCEnet concepts in the near term. "FnEP represents the operational construct for FORCEnet and demonstrates the power of FORCEnet by integrating a specific set of joint sensors, platforms, weapons, warriors, networks and command and control systems, for the purpose of performing mission specific engagements. Initial pack asset allocation and constitution will be based on a specific threat or mission however, the ability to dynamically reconfigure and reallocate assets 'on the fly' to reconstitute a new capability will enable cross-mission engagements." [Hesser/Rieken04] The FORCEnet factors form the foundation for the capabilities that FnEPs will provide. These capabilities are called the Combat Reach Capabilities: Automated Battle Management Aids, Integrated Fire Control, Composite Tracking, Composite ID, and Single and Common Pictures [Hesser/Rieken04]. FnEPs are used as the operational C4I system being evaluated in the MCES.

C.   MMOGS AND FORCENET

1.   Module 1 – Problem Formulation

Problem formulation is a critical step that must be completed prior to the design and testing of a C4I system with an MMOG. The objective of this step is to identify the decision makers and their objective for the evaluation. Other important parts of this step are to determine the type of analysis required for the system and select the initial scenarios and missions that will be used to test the system.

The objective of FORCEnet is to create an operational construct and architectural framework for naval warfare in the information age that integrates warriors, sensors, networks, command and control, platforms, and weapons into a networked, distributed combat force. The need for this system is derived from

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the inefficiencies present in the current utilization of military assets. In order to improve on current inefficiencies, issues such as the interoperability of assets, scalability, threat capabilities, connectivity, and bandwidth requirements must be addressed.

Prior to implementing solutions to these issues, research should be dedicated to determining whether the implementation of the FORCEnet concept will enhance combat effectiveness. One solution to this problem is to model an ideal architecture of FORCEnet in the virtual environment and analyze the improvements, if any, to operations and the outcomes of battles. These improvements can be identified by conducting scenarios in the virtual environment without the FORCEnet architecture in place to provide data for comparison. The FORCEnet modeled system can be used as a guide for issues that must be addressed in order to make the system a reality. The model can also be manipulated to a more realistic design when issues are resolved.

Determining the problem that must be addressed is the first step in framing the design of the MMOG. The next part of this module that will have a large impact on the MMOG is the selection of the initial scenarios and missions that will be used to test the system. Once these have been selected, the designers can begin creating the landscapes for virtual operating environments. The multitude of available virtual environments discussed in Chapter III is vital in this area, especially since FORCEnet theoretically covers any environment that forces will operate in ranging from urban combat to undersea. At a minimum, operational areas should include environments where the Navy and Marine Corps frequently operate to include oceans for blue water battles, littoral regions, ports, various land terrains, and a town or city for urban combat. For this particular example, oceans and littoral regions should be modeled.

Determining which analysis methods to use is vital in the handling of data gathered during the MCES process. Though this is a substantial area, this thesis does not focus on these methods to support the importance of using MMOGs to model C4I systems.

2. Module 2 – System Bounding

The goal of this module is to delineate the difference between the system being analyzed and its environment. Identified by its human, hardware and software components and structures, the system is related to the forces it controls and the environmental stimuli to which it responds, including the enemy. In the process of bounding the system, the structure of the system is more clearly defined by determining the physical layout to include the interrelationships of the components.

FORCEnet theoretically encompasses such a vast number of components that it would be virtually impossible to replicate them all in an MMOG. In effort to bound the system to a manageable size, a FnEP will be used in the MMOG. An FnEP can be viewed as an operational subsystem of FORCEnet that will exhibit all the traits of the overall system but with a reduced number of components. The reduction of overall components to be included in the MMOG enables designers to create an accurate depiction of the system in the virtual environment. Reducing the number of entities also reduces the number of variables in the MMOG thus enabling more effective data collection.

The physical components comprising the C4I system include those listed in Chapter II e.g. terminal devices, transmission media, switches and control. The components for an FnEP include assets located on ships, aircraft, submarines, ground vehicles, unmanned vehicles, weapons launchers, weapons, satellites, ground stations and handheld devices. Information can be inputted into the system via the array of available sensors and warriors, and transmitted through the network architecture created in this step.

Since FnEPs are operational constructs that can be specific to a particular mission or region, the FNeP strike pack that will be used in this evaluation will be configured for blue water and littoral areas. The components of the strike pack are a DDG, LCS, P-3, F/A-18, SSN, several UAVs, and shore missile systems as they come in range of the operating area.

Determining the physical layout of the system and the interrelationships between the components is a process that should be completed prior to modeling the system in the MMOG. For this example, the hypothetical physical architecture will resemble the following figure:
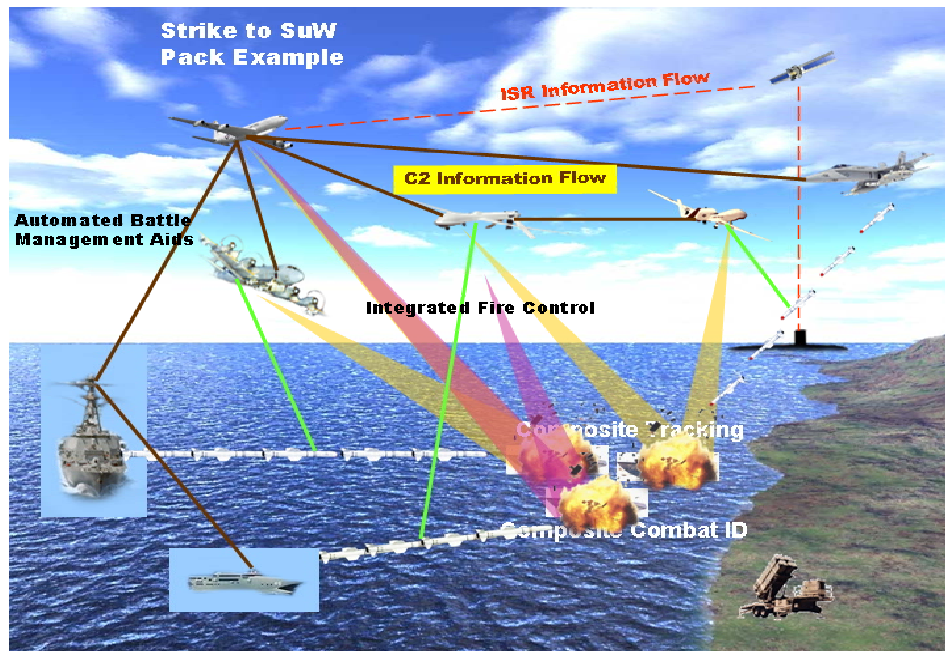
Figure 8.   FnEP Strike Pack Architecture [Hesser/Rieken04]

As mentioned in Module 1, an ideal architecture can be used, though it must maintain a relatively high degree of feasibility if it is ever to be implemented. Traditional models can be used to determine the most effective architecture for the system to include factors such as methods of data transmission and the necessity of additional components such as unmanned vehicles (e.g. aerial, surface and subsurface) to complete the system. Once the system is modeled in the MMOG, it can be adapted as necessary when insights are gained from analysis. The complete system will not fully be identified until Module four.

3.   Module 3 – Process Definition

Once the system is bounded and the entities comprising the system are identified, the dynamic C4I processes of the system are identified. The goals of this module are to identify the environmental initiators of the C4I process, the

internal C4I process functions, and the input to and output from the internal C4I process and the environment. The generic internal C4I process functions are sense, assess, generate, select, plan, and direct [Kramer87].

One of the objectives of the FnEP is to enhance the ability of the warfighters to carry out their mission. Theoretically, this objective is met by providing the warfighter the enhanced capabilities of the FnEP. The integration of the gamut of sensors present in the operational area and located on the FnEP strike pack assets will provide the warfighter with a heightened awareness of enemy actions, an accurate picture of the disposition and actions of friendly forces, and environmental factors that affect the area. Providing this information will enable the warfighter to assess the situation and, with the assistance of the C4I system, generate potential courses of action. Once the warfighter has selected a course of action and planned the implementation, the FnEP will aid in the direction of that course of action through the integration of the assets in the strike pack.

The C4I process is primarily what will be tested with the system modeled in the MMOG. The integration of the entities comprising the FnEP should increase the information available to the warfighter that will allow him or her to make a more informed decision on a course of action. The possible courses of action are also increased with the integration of weapon systems available to the warfighter. Once a decision has been made, executing the decision should also be easier due to inter-networking that allows for the rapid distribution of orders to forces executing the decision.

Testing the system in an MMOG is a logical step in determining whether the FnEP will meet its objective of enhancing warfighter effectiveness. This includes the ability of the FnEP to perform its assigned mission and to adapt to other mission assignments. An example of a change in missions is a shift from surface warfare to a missile defense role. If the FnEP proves to be successful, a secondary objective is to determine the amount of increased effectiveness. Other factors can be tested to determine its contribution to warfighter

effectiveness like the layout of information on C4I displays and emergent behavior. Depending on the analysis methods selected in Module 1, the analysts can gather information that will aid in identifying and comparing alternatives in structures, processes and HSI. Data for this can be generated by conducting experiments in the environment without the C4I system as a baseline for data. Any enhancements caused by manipulating the C4I system, the process functions of the users, and the available displays will then become more apparent when compared to the baseline data.

4.   Module 4 – Integration of System Elements and Functions

Module 4 strives to integrate the physical entities and structures identified in Module 2 and the C4I processes or functions identified in Module 3. Techniques such as data flow diagrams are used to model the information flow that controls these relationships. Once these relationships have been determined, the architecture of the system can be created. The compilation of the factors determined in the previous modules provides the quantitative information that can construct the system architecture in a static or dynamic mode. This architecture can now be modeled in an MMOG.

The operational landscapes selected in Module 1 should already be constructed in the virtual environment. The addition of the system architecture within the virtual environment will complete the entities to be tested. Additional game design will occur at this point to make the game functional. These include the creation of AI rules and characters, the development of an avatar library for users to select from, and ironing out the rules dictating the behaviors of avatars and objects in the virtual environment.

Once the MMOG is operational, it should be utilized by users to ensure a functional gaming environment prior to the beginning of testing. The beta test of the MMOG allows designers for obtain feedback from the users with respect to any bugs in the game, game balancing issues, and problems with game displays. This is also a good opportunity for users to become familiar with the user computer interface, maneuvering around the virtual environment, and

familiarizing themselves with the new capabilities that the FnEP provides. This will aid in attaining user proficiency with the game interface and the FnEP capabilities prior to the beginning of testing.

5. Module 5 – Specification of Measures

The objective of this module is to choose measures that will define the specific areas that are to be tested. These areas chosen should support answering the problem of interest determined in Module 1. Measures of Merit (MOM) are generically categorized as Measures of Force Effectiveness (MOFE), MOE and MOP. The most valuable measures for evaluating C4I systems in MMOGs are MOEs and MOFE.

MOEs are the core of the research effort with MMOGs. The objective throughout this thesis and in this evaluation is to evaluate the effectiveness of a C4I system on U.S. and coalition forces within an operational environment. MOFEs discuss the effect of the C4I system on enemy forces through the actions of friendly forces utilizing the system. Though these two types of measures are related, a distinction is necessary since an improvement in MOE does not necessarily translate into increased MOFE. For example, the composite tracking CRC of the FeEP may provide a more accurate picture of target locations but a lack of ammunition will void the benefits of the Integrated Fire Control, thus not changing the MOFE.

The primary difference of evaluating FnEPs using MMOGs instead of other methods is the ability of MMOGs to take into account the actions of human decision makers. MOEs and MOFEs should be selected in such a way that they will take into account the effects of the system on the decision makers. Comparative analysis of the MOEs and MOFEs can be made between the actions taken with a C4I system modeled within the virtual environment and without the system, and between various scenarios when the proper measures are selected. The comparison of these factors will provide the analyst with the information needed to determine the effect of the system on the decision maker.

### 6.	Module 6 – Data Generation

This module provides the opportunity to populate the measures determined in Module 5 with data. Data can be generated by a variety of methods such as exercises, experiments, simulations and models. Though a variety of data generators are possible, requirements exist for any method used: 1) the generator must be available to support the analysis, 2) the generator is focused on the mission area/analysis objectives of the evaluation, and 3) the generator is adaptable to produce, with minimal modification, the values associated with the measures specified Module 5. [Kramer87]

The virtual depiction of the C4I system in the MMOG creates the data generator to populate the measures selected in Module 5. A great deal of data can be gathered from MMOGs. The environment can be configured to record game play so that aspects of the game can be replayed for further analysis. Statistics on game play can also be collected ranging from the number of times a certain weapon is fired to the time it takes from the introduction of enemy forces to the reaction of friendly forces. Certain statistics that can be gathered from game play are limited to being useful for comparing various alternatives of architecture and process functions.

Data generation is not limited to quantitative information. Evaluators can evaluate qualitative factors such as innovations in decision making, asset deployment, emergent behavior and the benefits of HSI. Unlike the quantitative information, qualitative information can be gathered by observation of game play and feedback from users. These factors are not necessarily independent of the collected data. The degree of improvement can be supported by the data generated. An example is the effects of emergent behavior on the speed at which assets are deployed to defeat an enemy. The overall time to neutralize the enemy will be tangible data to compare with other scenarios.

Using an MMOG provides various methods to produce data. The evaluators of the system have options ranging from simulations to unrestricted game play. Running multiple simulations with the same architecture will allow

evaluators to compare results and identify significant data points. Unrestricted game play allows designers to evaluate the system for user trends over time and unexpected user behavior. Unrestricted play will also provide the opportunity for emergent behavior to form between users. If the MMOG contains AI that is entertaining to users, a great deal of data can be generated and qualitative information gained by users playing the game for fun.

7. Module 7 – Aggregation of Measures

The last module allows the evaluator to analyze and interpret the data gathered for the measures specified in Module 5. Various aggregation techniques should be considered, depending on the information gathered. The final outcome of this Module is to determine whether the decision maker's original queries were addressed by the MCES analysis. A report and graphics should be produced to provide documentation of the process.

A challenge to the evaluator is to sort through the mountain of data generated by game play and separate out the information related to the measures selected in Module 5. Though methods of data analysis are not the focus of this thesis, the amount of data produced allows for a variety of analysis tools to be applied. The output of the analysis gathered with the MMOG allows the evaluator to interpret the data and determine whether FORCEnet has met or fallen short of its goal of enhancing warfighter effectiveness.

C. SUMMARY

The advantages presented in this chapter illustrate the potential advantages of utilizing MMOG to evaluate C4I systems. By utilizing the MCES to evaluate FORCEnet, a reader can walk through the steps that determine the important factors to evaluate the C4I system from the identification of a need to data aggregation on the conceptual model.

The MCES process is lengthy and may take a great deal of time but can provide a plethora of valuable information. The use of an MMOG provides flexibility in methods of data collection and a great deal of data for the evaluator. MMOGs also provide the opportunity for evaluators to monitor game play to derive valuable qualitative information like the quality of game displays, how that information affects the decision maker and the innovative deployment of assets in the integrated environment. Unrestricted game play also provides the opportunity to evaluate the effects of a networked environment on decision making and collective decision making.

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V. CONCLUSION

A. CONCLUSIONS

This thesis has illustrated the potential benefits of using MMOGs to evaluate C4I systems. The background and history of MMOGs and C4I systems provided the foundation to identify the benefits of combining the two concepts. The use of the MCES process provided the opportunity to evaluate FORCEnet while identifying areas where the use of MMOGs would be most applicable and beneficial to the evaluation of the system.

B. AREAS FOR FURTHER RESEARCH

The information provided in this thesis provides the general layout of the benefits of using MMOGs. In order to delve deeper in the potential benefits of the technology, further research should be conducted in a variety of areas:

1. MMOG Design

The theoretical applications of MMOGs are discussed in this thesis in addition to commercial MMOGs that are currently in use. Further research should be conducted into the area of designing an MMOG intended for evaluating a C4I system. The actual construction of an MMOG with a modeled C4I system will allow for a better understanding of the potential insights afforded by the technology. In the process of creating the MMOG, design challenges should be addressed to include the selection of an appropriate game driver, the creation of the environments, populating avatar and object libraries, modeling the system being tested, ironing out bugs in the game, and game balancing. Additional issues such as creating the rules for users to access the game (e.g. passwords) and the utilization of the game environment between scenarios and unrestricted game play should be addressed.

2. Analysis Methods

Though data collection and analysis was referred to in Chapter IV, no methods were suggested for either process. This is a particularly valuable area that requires further research. The value of MMOGs can only be realized if data from the scenarios can be extracted and analyzed to support design weaknesses and strengths. Data is also necessary in evaluating whether certain features in the C4I design enhances or deters the performance of troops and if the mission is conducted more efficiently. The experimental design that will produce the analyzable data must also be researched. In effort to give the evaluators more flexibility in collecting usable data, evaluators should be able to change the independent variables in accordance with the experimental design and have the data collection mechanisms record the changes in such a way that the dependent variables can be associated with the appropriate settings of the independent variables.

3. Cost/Benefit Analysis

The issues of cost were not explored in this thesis. In reality, the design and maintenance of an MMOG is extremely expensive. The average production of commercial MMOGs in 2001 involved 20-40 people and $7-14 million [Herz02]. These figures to not include the cost of maintaining the MMOG once it is in operation. The commercial industry has the benefit of defraying the maintenance and initial design costs with monthly subscription fees. Since this will not be an option for an MMOG used by the military, all costs will be the responsibility of the sponsoring command.

The cost of designing and maintaining an MMOG must also be compared to the value of the benefits provided by the technology. Though the potential exists to extract valuable information derived from unrestricted game play and scenarios conducted in the virtual environment, the cost of maintaining the environment in dollars and man-hours may exceed the benefits.

Another cost issue involves the bandwidth that is required to maintain a smooth picture for all the users. Irrespective of the location of the users participating in the MMOG, a great deal of bandwidth will be required. This can be a potential problem if users are remotely located and have limited connectivity. The bandwidth issue can be minimized by ensuring users access the MMOG via land connections with a large bandwidth but this restriction will limit the types of users that can be part of the evaluation process.

4.   Additional Uses for MMOGs

Only one potential use of MMOGs has been explored in this thesis. This technology has the potential to be used in other capacities that can be beneficial to the Department of Defense. Other potential applications include using MMOGs as a testing and collaboration forum, gaining insights on adversaries and their warfighting tactics, and an innovation forum. A testing and collaboration forum entails a broad use of MMOGs. Like C4I systems other assets can be modeled in the virtual environment and can be tested by the users interacting with the model. An MMOG can provide a collaboration environment by encouraging users from various civilian and government agencies to interact in an MMOG to build a rapport. A familiarity between agencies can provide a significant advantage when a conflict or situation arises.

The multitude of users provides an environment to gain insights on adversary tactics and a better understanding of cultural differences. One option to gain insights into the adversary is to allow unrestricted game play of U.S. Forces to play against a professional Red Team that is well versed in the adversary mindset and tactics.

The innovation forum involves a great deal of unrestricted game play by users. Allowing a consequence-free environment for experimentation emphasizes creativity and innovation in the utilization of assets, combat tactics and concept development. Users will also have the opportunity to test various

alternatives of battle plans prior to applying one in a real combat situation. Another benefit to the innovation forum is a better understanding of the direct, indirect and cascading effect of operations.

LIST OF REFERENCES

[AboutAI.net] "AI in Computer Games"
http://www.aboutai.net/DesktopDefault.aspx?tabindex=1&tabid=2&article=/aa111600a.htm 23 Mar 04

[America's Army] America's Army Screenshots
http://www.americasarmy.com/gallery/ 16 Jan 04

[Bean94] Bean, Theodore. "System Boundaries Within the MCES Paradigm." Phalanx, June 94; p 23-26.

[Bray04] Bray, Hiawatha. "Game On; For Camers, World War II Rages on Old-Fashioned Clash of Good vs. Evil is a Computer-Age Hit." The Boston Globe, January 7,2004; p D1.

[DSB01] Defense Science Board 2001 Summer Study on Defense Science and Technology. May 2002; p12-13.
http://www.acq.osd.mil/dsb/sandt.pdf 23 Mar 04

[EuropeMedia02] "The Market for Massive Multiplayer Online Games is 'Tremendous'." EuropeMedia. 9 October 2002.

[Everquest04] "What is Everquest?"
http://everquest.station.sony.com/about.jsp 23 Mar 04

[Game Daemons03] "Netfire to Host America's Army in Europe – Includes Game Daemons."
http://www.gamedaemons.net/interface.gdx?view=documents-press&id=69 23 Mar 04

[Gehorsam03] Gehorsam, Robert. "The Coming Revolution in Massively Multiuser Persistent Worlds." Entertainment Computing. April 03, p 95-97.

[Herz02] Herz, J.C. "Harnessing the Hive: How Massively Multiplayer Online Games Drive Networked Innovation." November 2002.

[Hesser/Rieken04] Hesser, Robert W., and Danny M. Reiken. "FORCEnet Engagement Packs: "Operationalizing" FORCEnet to Deliver Tomorrow's Naval Network-Centric Combat Reach Capabilitis…Today." Naval Postgraduate School Thesis. March 2004.

[Highlands ForumXX] Executive Summary. Highlands Forum XX – Massively Multiplayer Online Games. 4-6 December 2002.

[id Software04] id Software Backgrounder.
http://www.idsoftware.com/business/history/ 23 Mar 04

[Joint Pub 1-02] Definitions Related to Command and Control.
http://www.dtic.mil/jcs/j6/j6v/migration/definitions.html 23 Mar 04

[JCS Pub 6-0, 95] "Executive Summary." Joint Pub 6-0. 30 May 1995 p. vii –
ix.

[KoreaHerald04] Mi-Young, Kim. "Korea Grapples with Game Addicts; But
Many Say Tough Regulation Unlikely on W500 Billion Industry." The Korea
Herald. 13 January 2004.

[Kramer87] Kramer, Gail. "Application of the Modular Command and Control
Evaluation Structure to a Strategic Defense Initiative C2 System." NPS Thesis.
March 1987.

[Lineage04] Lineage Online Manual.
http://www.lineage.com/guide/gs_guides.html 23 Mar 04

[Maney03] Maney, Kevin. "Military Strategists Could Learn A Thing or Two
From the Sims." USA Today. 2 April 03, p 3B.

[MASA Group] "Military Simulation and Training; MASA's Military Plaltform."
http://www.animaths.com/index_military.htm 23 Mar 04

[McGregor01] McGregor, D. Kapolka. "NPSNET-V: An Architecture for
Creating Scalable Dynamically Extensible Networked Virtual Environments."
Unpublished presentation iven at the 2001 MOVES Institute Open House, Naval
Postgraduate School.

[Miller/Thorpe95] Miller, D., and J.A. Thorpe. "SIMNET: The Advent of
Simulator Networking." Proceedings of the IEEE. August 1995.

[Moore96] Moore, James F. "The Death of Competition: Leadership and
Strategy in the Age of Business Ecosystems" Harper Business, 1996.

[Pendergrass93] Pendergrass, William Stanley. "Combat Analysis for
Command, Control and Communications: A Primer 1993 Edition." NPS Thesis,
June 1993.

[Proceedings02] Clark, Vern. "Projecting Decisive Joint Capabilities."
Proceedings, October 2002.

[Serin02]   Serin, Ekrem.   "Design and Test of the Cross-Format Schema Protocol (XSFP) For Networked Virtual Environments."   NPS Thesis, March 2003.

[Singh97]   Singh, G.   Personal Communication with Michael Zyda, July 25, 1997.

[SSG00]   "Naval Power Forward."   Strategic Studies Group XIX, September 2000.

[SSG01]   "FORCEnet and the 21st Warrior."   Strategic Studies Group XX. November 2001.

[SSG03]   "Sea Supremacy in the context of SEA POWER 21," Strategic Studies Group XXII Quick Report.   August 2003.

[Zyda99]   Zyda, Michael and Sandeep, Singhal.   <u>Networked Virtual Environments; Design and Implementation</u>.   ACM Press. 1999

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